Appendix I. Curtailment Documents

Curtailment Strategy

Glenrock and Rolling Hills Wind Energy Facilities

Converse County, Wyoming

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INTRODUCTION

PacifiCorp has developed the Glenrock & Rolling Hills Wind Energy Facility (Project), in Converse County, Wyoming. PacifiCorp requested that Western EcoSystems Technology Inc. (WEST) create a document detailing the process of developing, implementing and refining the on-going curtailment program at the Project. The Project is located approximately 13 miles (20.9 kilometers [km]) north of Glenrock, Wyoming. Topography is a mix of rolling to steep hills and elevations range from approximately 5,750 to 5,898 feet (ft; 1,750 to 1,795 meters [m]). The Project is located primarily on a reclaimed coal mine, which has been restored through grading and seeding efforts. The land cover onsite is a mix of grasslands and sagebrush communities and encompasses in excess of 14,000 acres (more than 21.9 square miles [mi^2]) of land that extends approximately 12 miles (19.3 km) from north to south and is approximately 2 to 3 miles (3 to 5 km) wide.

Post-construction mortality monitoring was conducted at GRHWEF from 2009-2012 in accordance with US Fish and Wildlife Service (USFWS) recommendations (Johnson et al. 2012). In response to eagle fatality discoveries during these surveys, USFWS recommended implementation of advanced conservation practices (ACP) to reduce eagle take. PacifiCorp worked with WEST to develop a Project-specific ACP strategy that included experimental active curtailment of wind turbines. Curtailment for this document consists of eagle observations occurring from two stationary towers and manually stopping predefined groups of turbines from spinning when eagle risk is observed (Figure 1). The curtailment program began in November 2012 with the goal of reducing eagle mortalities and has continued to the present (March 2020).

This document was created to outline the process PacifiCorp undertook to develop the curtailment program and tailor the program for the Project. It includes discussion of the initial experimental period, transition to informed curtailment, and adaptive management.

CURTAILMENT STRATEGY

Process Overview

The initial framework for experimental curtailment began in late 2012, using a conservative approach of active curtailment by three biomonitors (i.e., biologist observing for eagles), 365 days a year, from sunrise to sunset. Curtailment was conducted under this framework from November 2012 – March 2015. Based on data collected and lessons learned during the experimental period, the program was evaluated and transitioned to an informed curtailment program. Review of the curtailment program at the Project continues, and adaptive management actions are implemented as warranted.

Experimental Curtailment Program Development

In 2012, curtailment was a fairly novel conservation strategy to reduce eagle risk, still considered experimental by the wind industry and regulatory agencies. Protocols had not been developed and long-term success had not been proven. However, PacifiCorp was limited in the actions they could take to reduce eagle mortalities during operational phases, as it has a responsibility to provide reliable energy to its customers and shutting down the project, or wind turbines on a large scale, was not a viable option. Limited curtailment was implemented by identifying eagle risk near wind turbines and reducing that risk by shutting down wind turbines. PacifiCorp worked with WEST to flesh out the program specifics, implement the strategy, and determine if curtailment was a viable long-term ACP to reduce eagle mortality at the Project.

The first steps included reviewing project-specific and publicly available data to understand general eagle ecology and associate that with observed/assumed Project risk. Comparisons of fatality rates across the Project as well as known eagle use patterns were evaluated. Additional landscape assessments were conducted to establish optimal observation locations, determine the number wind turbines and size of viewsheds that could be managed by a single observer for successful curtailment, and determine locations of visible/non-visible areas throughout the Project. These evaluations were followed by discussions with PacifiCorp to establish the number of biomonitors used to perform the curtailment, with three biomonitors determined to be adequate. While areas of known high eagle use were to be targeted by biomonitors, a decision was made to allow biomonitors to move within assigned sections (North, Middle, South) to support observations and curtailment on a day to day or hour to hour basis. Early curtailment was performed from vehicles or high points dependent on weather conditions.

Discussion with PacifiCorp and operations staff persisted to determine physical logistics for real-time curtailment. It was decided that biomonitors should radio O&M operation personnel who in turn would manually curtail wind turbines. The physical curtailment of wind turbines takes approximately 1-2 minutes. In an effort to take a conservative and efficient approach, curtailment zones were established. Curtailment zones consisting of groups of wind turbines to be curtailed collectively were established throughout the Project. Zones were determined based on several factors, including known and predicted eagle activity, distance from observation points, and electrical circuits among wind turbines. Twenty-three zones each consisting of five to 13 wind turbines were developed (Figure 1).

Resources were also developed for biomonitors to assist with the eagle observation and curtailment effort. An informal protocol was developed to identify when/how curtailment should occur, and included consideration of an eagle's distance from wind turbines, flight trajectory and speed, and perch locations, but still relied heavily on the biomonitor's professional judgement. PacifiCorp placed an emphasis early in the curtailment program that a conservative approach should be taken to maximize eagle risk reduction. The conservative approach included curtailing turbines in situations where large birds could not be confirmed as eagles, keeping turbines curtailed if visual observations of eagle were lost, but eagle was still potentially in the area, weather/visibility default shut downs, or other flight patterns or location identification that could not be confidently pinpointed but may result in risk. Additionally, Project area maps and datasheets were created for tracking curtailment activities and eagle use, both spatially and temporally (Appendix A). Maps included turbine and zone locations and datasheets included information on weather and visibility, as well as eagle observation data. The datasheets and maps were set up to collect eagle use/curtailment data that could be analyzed if required at a later date. Time and duration of eagle observations, distance to closest turbine, habitat data, flight height and direction, activity (e.g., perched, soaring, hunting), and observer location were included data fields.

Biomonitors were selected based on their experience and knowledge of eagle and raptor behavior, specifically in the region. They were trained in proper data collection, curtailment decisions, and use of equipment. Training also included shadowing an experienced biomonitor for a period of time, and periodic reviews with a supervisor. Collected data were regularly reviewed by managers to verify appropriate curtailment actions (e.g., flight path locations relative to turbines and curtailment call in times and shut down times), provide feedback on curtailment calls and data collection, and to allow the manager to be kept abreast of current eagle activity or changes in activity. These data were used to inform future curtailment efforts (e.g., better understanding hotspots or seasonal activity changes). All data were entered into an access database or digitized in ArcGIS.

The Experimental Curtailment Program began in November 2012 essentially as a test month with the purpose of verifying and refining the process and hiring staff to increase the number of available biomonitors. Curtailment took place during all daylight hours Monday through Friday using two observers. Biomonitors surveyed for eagles and curtailed turbine zones from vehicles at predetermined observation points. Based on the first trial month, PacifiCorp moved forward with a full-fledged curtailment program. In December 2012, the curtailment program was scaled up to include all daylight hours seven days a week using three biomonitors. The curtailment program continued relatively unchanged from December 2012 through March 2015.

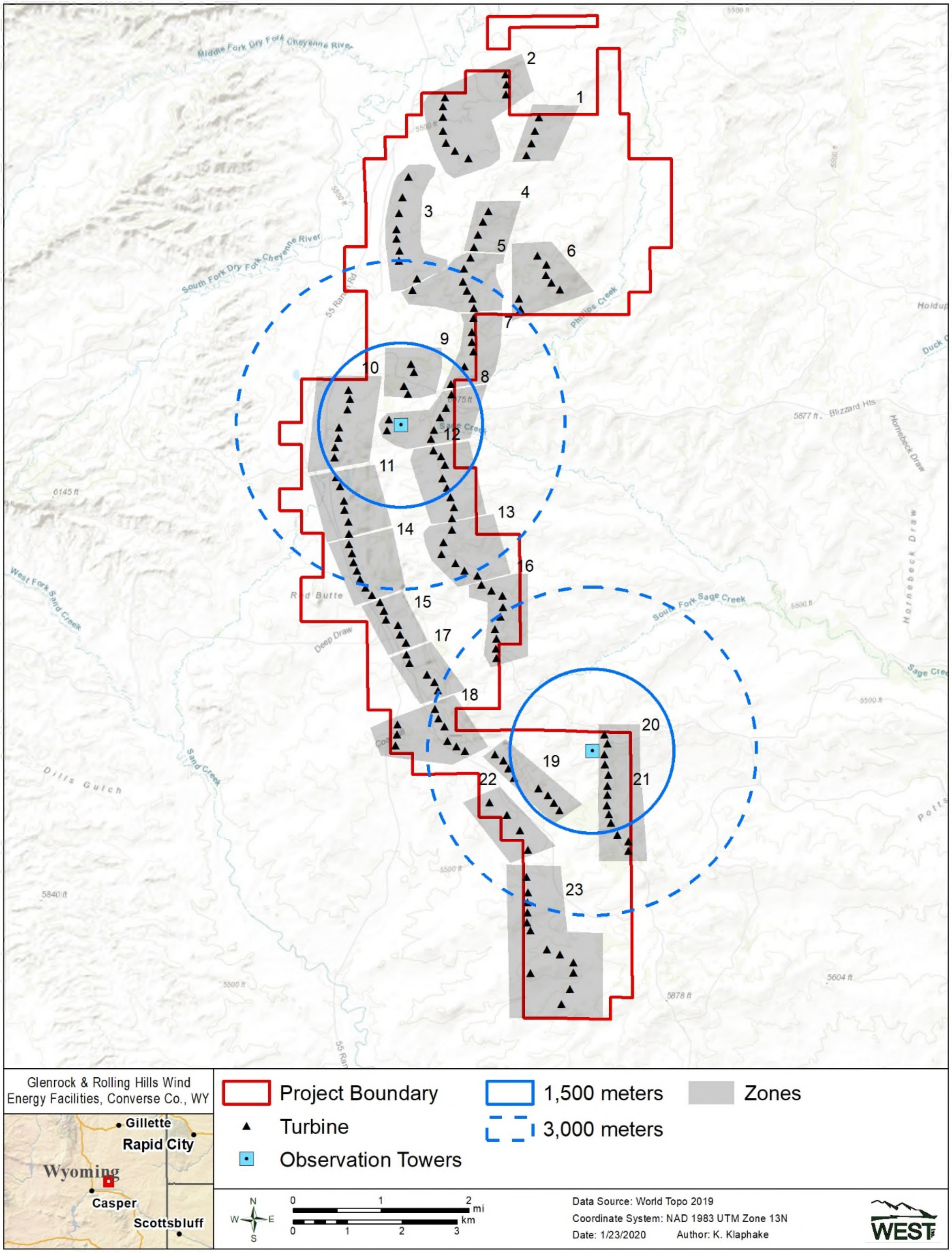

Figure 1. Curtailment zones and observation towers established at Glenrock and Rolling Hills Wind energy facility Converse County Wyoming.

Based on experience gained by the operations personnel and biomonitors over the experimental curtailment period, a number of modifications were made to the curtailment program. A brief list of modifications are provided below. While these modifications resulted in changes to the day-to-day curtailment implementation, the overarching protocol design remained consistent.

- A default curtailment area (pre-determined risky wind turbines) was established whenever the Project or sections of the Project could not be accessed or observed due to road closures, drifting, or visibility issues. This included 20 wind turbines categorized as north, middle, or south locations that would be curtailed during daylight hours as appropriated based on conditions (Figure 2). These turbines were selected due to previous eagle mortalities identified at the turbines.
- Observers limited movement to target areas that continued to demonstrate high eagle use and/or provided the best viewsheds. The most common observation locations for the north, middle, and south sections are plotted on Figure 2. These locations correlated specifically with turbines and turbines strings where mortalities had occurred and where viewshed maximized observations.
- Observers were provided a secondary communication unit to allow for communication among biomonitors outside of the operation’s channels; this allowed eagle movements to be shared among observers in real time.
- Observers rotated positions throughout the day to reduce landscape fatigue.
- Observers were provided breaks to eat, use bathrooms, and generally reduce fatigue (specifically in the longer summer periods).
- Maps continued to be updated with eagle use data, mortality data, and seasonal nest data to further inform observers on eagle activity. Appendix B provides example resources provided to biomonitors.
- New curtailment and data collection specific guidance documents were developed to further formalize the protocol. The documents were reviewed prior to each curtailment season and updated as appropriate.
- Gear (specifically binoculars) was purchased to ensure observers had equipment sufficient for the task at hand.
- Long-term WEST biologists were periodically brought in for curtailment stints to qa/qc the protocol, provide staff with observation tips/trick, and provide breaks for long-term biomonitors.
- It was decided that curtailed wind turbines would remain shut down for at least 10 minutes to reduce wear and tear on the units and reduce repetitive actions.
- In situations where eagle activity was high, biomonitors would prioritize areas most at risk or curtail individual zones where risk was constant and focus attention in areas where risk was sporadic.
- Collecting curtailment data became a secondary priority to eagle observations and curtailment.
- In some instances, areas where eagle activity was observed but no mortalities were documented were identified as non-target areas. Biomonitors were less focused on eagle observations and curtailment along these strings. However, if eagle risk was observed, the same curtailment protocol was implemented.

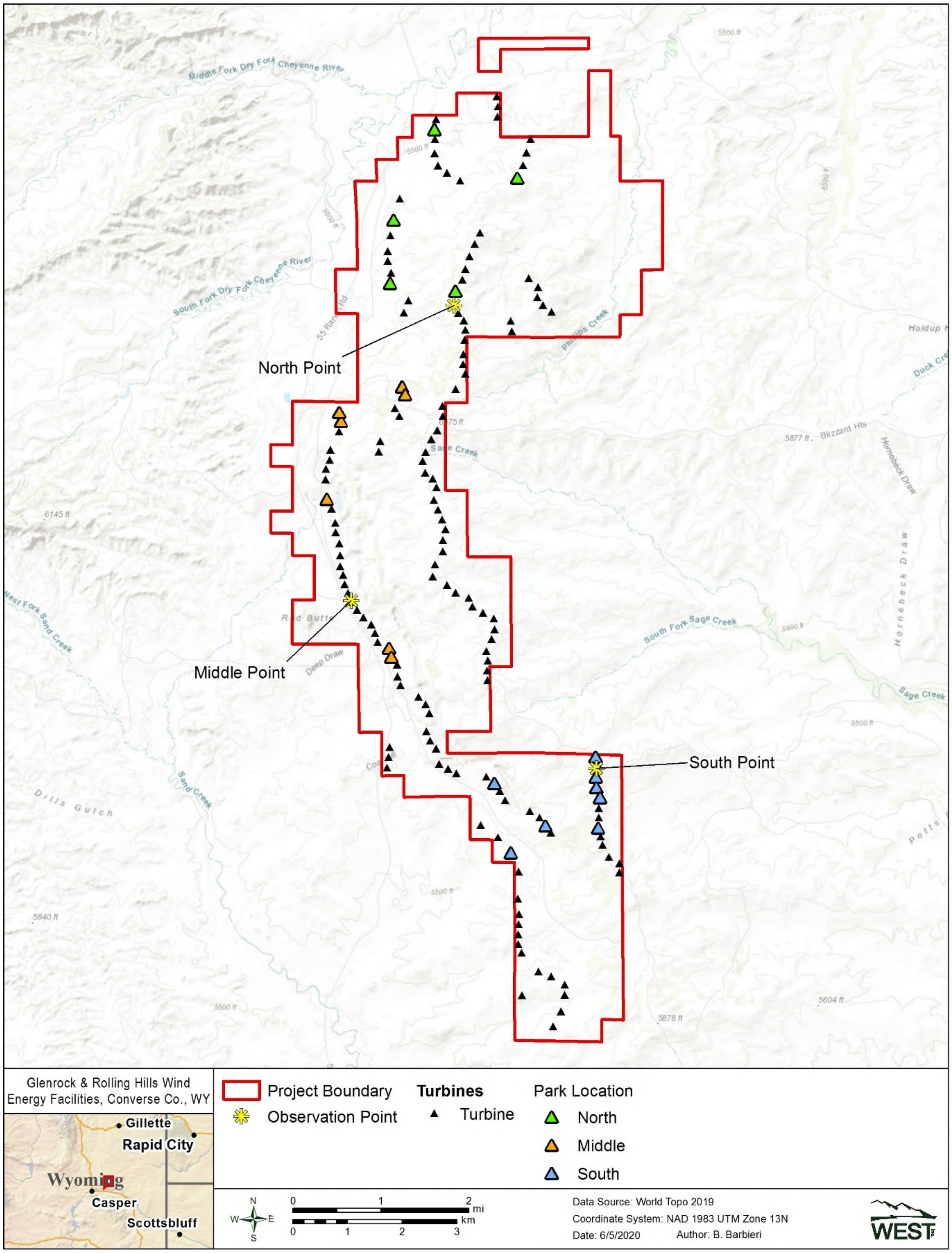

Figure 2. Original default curtailment turbines and common observation locations at Glenrock and Rolling Hills Wind energy facility Converse County Wyoming.

- Weekly meetings occurred among staff to share information on eagle activity, health and safety, general concerns, tips/tricks, and ask questions.
- Periodic meetings were held with PacifiCorp and operations personnel to discuss the protocol and determine if changes were warranted.

Data Evaluation

As the experimental curtailment program continued, PacifiCorp expressed a desire to move into an informed curtailment program that could be maintained over the life of the Project (or until no longer deemed necessary). To help define the informed protocol, collected data on eagle use and curtailment of the Project were evaluated. All tabular data entered into the database and all flight paths digitized in ArcGIS were used. Because the data were not collected in a standardized manner (e.g., observation locations or dependent on eagle activity) some limitations to perform a statistically rigorous analysis were evident. As such, the analysis focused on eagle use/curtailment comparisons to a small number of major attributes:

- Curtailment vs. time of day
- Curtailment vs. month of year
- Curtailment vs. location
- Eagle use vs. time of day
- Eagle use vs. month of year
- Eagle use vs. location
- Eagle flight vs. eagle perch
- Eagle use vs. topography
- Eagle use vs. wind

The analysis produced useful information that provided indications on when and where curtailment was most effective. Figure 3 visually depicts golden eagle flight path intensity across the Project (based on observation data [November 2012 – December 2014]) and the section below is taken from the report's executive summary (WEST 2015):

Golden eagle flying activity was highest in the 1200 hour (13.3% of all flying observations). Over 75% of the flying observations occurred from 1000 to 1600. Observations within the rotor swept zone were also highest during this time period. The number of eagles observed perching varied throughout the day, but the peak numbers were observed perching in the early morning.

Approximately 72% of observation minutes were of perched eagles, while observation minutes of flying eagles accounted for 28%. Peak flying minutes (proportion) were observed in the 1200 hour (13.3%). Approximately 50% of the flying minutes (proportion) occurred from the 1100 – 1400 hour, while approximately 75% of the flying minutes (proportion) occurred within the 1000 – 1600 hours. Perch observation minutes (proportion) were greater in the morning; however, perching consistently occurred from the 0600 – 1600 hour.

Eagle observation minutes varied throughout the year. The highest percentage (proportion) of flying minutes occurred in December (18.1%), January (16.1%), November (15.0%), and

February (12.0%). The lowest percentage (proportion) of flying minutes occurred in June (2.5%), May (2.8%), April (2.8%), and September (3.9%).

Eagle activity varied throughout the project area. Eagle activity was most concentrated in the south study area west of turbine string GR3-601 to 613 and in the north study area north and west of GR1-105 to 208. Other concentrated activity was located along the slope west of GR1-301 to 414. Flight paths tracked north and south above the slope. High activity was also recorded around Red Butte (west of RH3-403).

Analysis of topographical data suggests that as the slope increases, eagle observations increase. The increase is more evident at lower slopes. There was little difference in eagle activity as a function of aspect, although west aspects (225-315 degrees) had the highest proportion of flight paths, followed by north aspects (315-45). South aspects (135-225 degrees) and east aspects (45-135) had the lowest proportion of flight paths.

In general, activity by flying eagles increased with increasing wind speed. Eagle counts were relatively low at wind speeds < 7 meter/second (m/sec). Eagle activity began to increase once wind speeds were 7 m/sec, and continued to increase until wind speeds were 12 m/sec. A small decrease in the proportion of eagle counts was observed when wind speeds ranged from 13-17 m/sec. A peak in activity occurred when wind speeds were at 19 m/sec; however, this was based on a limited number of survey hours.

The number of turbine curtailments and minutes varied throughout the day. Approximately 50% of the curtailments occurred within the 1000 – 1400 hour period and greater than 75% occurred within the 0900 – 1700 hours. The number of turbine curtailments increased from sunrise until 1200, and then decreased over the remainder of the day. Greater than 50% of the curtailment minutes occurred within the 1000 – 1500 hour period and approximately 75% of the curtailment minutes occurred from 0800 – 1600. Curtailment minutes increased from sunrise until the 1200 and 1300 hours, then decreased over the remainder of the day.

The number of turbine curtailments and minutes varied across the months of the year. The highest proportion of turbine curtailments occurred from October – March (78.5% combined). Proportion of curtailments by month over this period were December (15.9%), January (15.6%), November (14.4%), February (14.1%), March (9.3%), and October (9.2%). The lowest proportion of turbine curtailments occurred from April – September (21.7% combined).

The 158 wind turbines were grouped into 23 zones for purposes of curtailment. Zones 20 (7.7%), 21 (7.9%), 19 (6.8%), and 23 (6.3%) had the greatest proportion of turbine curtailments. Zones 5, 8, and 14 each had at least 5% of the curtailments. Zones 1, 6, 9, 10, 15, and 17 had 2.5% or less of the curtailments. Curtailments occurred most often in the south section (37.2%; zones 18 – 23) and middle section (35.4%; zones 8 and 10 – 17) than the north section (27.5%; zones 1 – 7 and 9). Zones 23 (9.7%), 20 (8.7%), 21 (6.8%), and 19 (6.6%) had the greatest proportion of curtailment minutes. Zone 4, 14, 18, and 22 had at least 5% of the curtailment minutes. Zones 3, 6, 9, 10, 15, and 17 had less than 2.5% of the curtailment minutes. The south (42.0%; zones

18-23) had the highest percentage of curtailment minutes, followed by the middle (31.9%) and the north (26.1%).

Because eagle flying activity in very close proximity to wind turbines presents the greatest inherent risk, we also summarized the length of eagle flight paths within a 100 m-radius of wind turbines to further assess risk to golden eagles at the GRHWEF. We believe that this metric is likely the most closely associated with risk of any metric examined in this report. This analysis confirmed that risk to golden eagles is highest along Glenrock turbine strings GR3-601 to 613, GR1-411 to 414, GR1-501 to 508, and GR1-105 to 115. Risk along Rolling Hills wind turbines appeared low based on flights within 100 m; however, more golden eagle carcass discoveries have occurred at these wind turbines. Rolling Hills turbine strings with the highest risk are RH3-401 to 405, RH1-601 to 615, RH1-504 to 509, RH1-304 to 308, and RH1-201 to 206. Although some wind turbines with high activity did not have eagle carcass discoveries and others with low activity did, when eagle flight activity within 100 m of wind turbines was combined with data on where previous eagle carcass discoveries have occurred, there is a relationship between these two parameters, as most of the eagle carcasses were discovered at wind turbines with high eagle flying activity within 100 m, specifically along Glenrock wind turbines. Months with the highest mean length of eagle flight paths (per survey hour) within 100 m of wind turbines were January, February, March, October, November, and December. During each of these months the mean length of flight paths within 100 m of wind turbines was well over 100 meter/hour (m/hr), with January, November, and December over 200 m/hr. In contrast, the months with the lowest mean length of flight paths within 100 m of wind turbines (April - September) each had less than 65 m/hr of flight paths within 100 m of wind turbines. The mean length of eagle flight paths within 100 m of wind turbines was highest in the 1200 hour (~200 m/hr), and was also relatively high (i.e., > 100 m/hr) from the 1000 through 1600 hour. Higher activity by eagles in close proximity to wind turbines also occurred at wind speeds greater than 9 m/sec.

These results were used to move the curtailment program from the experimental phase to the informed phase. Additionally, these data were used to better inform biomonitors of eagle use patterns at the Project.

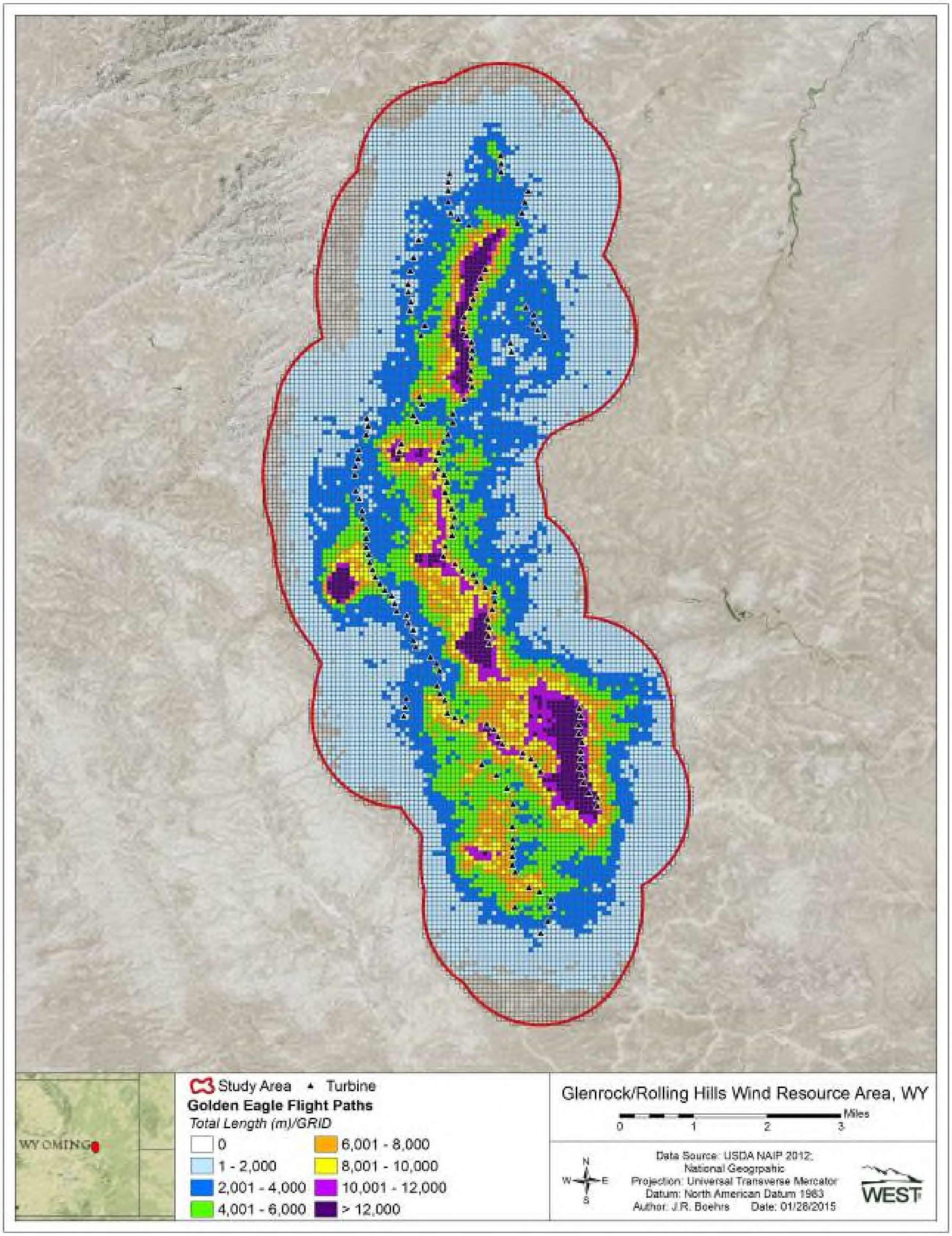

Figure 3. Eagle flight paths (not standardized) collected during the curtailment period (Nov 2012 – Dec 2014) at Glenrock Rolling Hills Wind energy facility, Converse County Wyoming. Grid size is 100 m x 100 m.

Informed Curtailment Program Development

Given the success achieved during the experimental curtailment program, PacifiCorp initiated the transition to a long-term informed curtailment program. This included the development of a protocol that would be efficient and sustainable, while still targeting eagle risk reductions. PacifiCorp used the curtailment analysis report to determine the highest risk periods. It was determined that October through March should be the target curtailment season and 0900 through 1600 should be the target daily curtailment period. Additionally, PacifiCorp determined that two biomonitors would be used moving forward. The informed curtailment program was initiated in October 2015. The actual written protocol is provided in the next section.

To support the two biomonitor system, and create additional efficiencies in the curtailment process, PacifiCorp constructed two stationary observation towers (Figure 1). These towers provided better working conditions, increased viewshed, and were set up to allow biomonitors to curtail wind turbines themselves, reducing the need to radio operations personnel for each curtailment request.

Prior to constructing the observation towers, PacifiCorp worked with WEST to identify the optimal tower locations. This included a feasibility analysis based on eagle spatial use across the Project, visible/non-visible areas to maximize viewshed quality, and constructability. The locations also had to be chosen to ensure the tower itself was visible to the repeater system that would allow access to the Supervisory Control and Data Acquisition (SCADA) system. The southern Project area provided the most optimal location due to high eagle use and high quality viewsheds, and was therefore selected as one of the tower locations. While the northern Project area had eagle use and mortalities, the more rugged topography in this area limited viewsheds and constructible locations; therefore, the second tower was located in the north-central Project area. From these locations, nearly 100% of the turbine rotor-swept-areas were visible. Each tower was outfitted with two computer screens, one for the SCADA that controlled wind turbines and provided the ability to curtail from the tower (i.e., no call in required), and one to maintain a curtailment log and communicate with PacifiCorp/operations personnel.

To support the informed curtailment program, PacifiCorp provides annual SCADA operation and safety training to the biomonitors. Data collection on eagle use and behavior has continued, but the emphasis continues to be eagle observation and curtailment. PacifiCorp has maintained the informed curtailment program from October 2015 through the present (January 2020) and plans to continue the program into the future. Adaptive management has occurred as needed throughout the curtailment period (see section below) and will be implemented as needed into the future.

During the fall 2017 curtailment season PacifiCorp initiated curtailment one month early (September) and added a third observer due to increased eagle activity and subsequent curtailment needs. The third observer was located in a vehicle and was either stationed in the northern Project area or along the western Rolling Hills turbine strings. The third observer was retained for January and February 2018. PacifiCorp chose to increase the curtailment effort due to early and increased eagle activity identified across the Project. A specific threshold for changes to the protocol have not been established.

CURTAILMENT PROTOCOL

A formal protocol was developed for the informed curtailment program. This protocol was included as an attachment to the Migratory Bird Compliance Plan (Attachment 2) and is provided here unchanged as the protocol document has not been updated since inclusion in this document. Changes to the written protocol are captured in Table 1.

Attachment 2

Initial Informed Curtailment Protocol

Glenrock/Rolling Hills/Glenrock III (GRH) Wind Site

and

Seven Mile Hill/Seven Mile Hill II (SMH) Wind Site

This Informed Curtailment protocol applies to PacifiCorp's Glenrock/Rolling Hills/Glenrock III (GRH) Wind Site and Seven Mile Hill/Seven Mile Hill II (SMH) Wind Site during established time periods and conditions. "Informed Curtailment" means the use of biological monitors stationed at a Wind Site, when safe to do so, that have the capability to call for curtailment of one or more turbines based on the protocol set forth in Attachment 2.

The informed curtailment of wind turbine generators due to eagle proximity is an experimental ACP method intended to help reduce potential turbine collisions with eagles. The goal of informed curtailment is to identify risky eagle flight behavior/pathways and notify site personnel prior to potential turbine interaction. Curtailment of turbines will be based on knowledge of eagle activity and observed behaviors for the GRH Wind Site and the SMH Wind Site. An observer will notify site personnel whenever eagle flights are observed near/toward individual turbines or a grouping of turbines. An observer will also notify site personnel when risk is reduced to an acceptable level to release the turbine or grouping of turbines from curtailment.

Due to the geographic extent of the GRH Wind Site and the SMH Wind Site, an observer may not be able to visually identify every eagle in the vicinity of turbines. Positioning of an observer will be as appropriate to maximize eagle detection in known eagle high use areas. An observer will be mobile, as necessary, to best detect potential risky flights by eagles. The location of an observer may also be altered over time as eagle activity changes at the GRH Wind Site or the SMH Wind Site.

An observer will notify site personnel of a recommendation to implement turbine curtailment if:

- Eagle(s) are observed within 800 meters of a turbine or grouping of turbines;
- Eagle(s) flight paths are reasonably likely to cross through or near turbine(s) based on observed heading or assumed trajectory;
- Eagle(s) are observed actively foraging within or near turbines or a group of turbines; or
- Any other behavior is observed in which an observer believes it is reasonably likely that an eagle(s) is moving toward a potential collision with a turbine.

An observer will use their professional judgment based on knowledge of the GRH Wind Site or the SMH Wind Site and eagle behavior; *however*, it is understood that eagle activity and other environmental variables (e.g., wind conditions) are unpredictable.

An observer will monitor eagle activity while within sight, or until a higher priority risk is observed (e.g., eagle approaching turbines). An observer will notify site personnel with an "all clear" once eagle risk is reduced to an acceptable level as determined by the observer. Site personnel will notify the observer when turbine curtailment has ended. The following is a list of factors that an observer will consider when deciding when to notify facility personnel to resume turbine activity:

- No eagle activity has been observed for 10 consecutive minutes in a turbine group;
- Eagle is perched beyond 800 meters from closest turbine or turbine group;
- Eagle flight direction observed away from turbines or turbine group and eagle is beyond a 1,600 meter buffer;
- Eagle is observed increasing elevation above turbines or turbine group in patterned behavior at least 400 meters above ground level; or
- Time of day, visibility, or other factors.

Informed Curtailment will not occur if weather conditions create potentially unsafe conditions for an observer, or if observer visibility is heavily impaired.

Under this Protocol, PacifiCorp will employ biological monitors for the purpose of Informed Curtailment according to the following schedule:

GRH Site – Two biological monitors seven days per week, seven hours per day (0900 hours to 1600 hours, Mountain time), during the months of October, November, December, January, February and March.

SMH Site – One biological monitor seven days per week, five hours per day (0900 hours to 1400 hours, Mountain time), during the months of January, February, and March.

Modifications to this protocol may be warranted over time as new information becomes available.

ADAPTIVE MANAGEMENT

According to the USFWS Land-based Wind Energy Guidelines (USFWS 2012), adaptive management is a process that promotes flexible decision-making as outcomes from management actions and other events become better understood. The Eagle Conservation Plan Guidance (USFWS 2013) considers adaptive management of experimental ACPs a necessary aspect in developing the establishment of formal ACPs. In keeping with the adaptive management approach to the curtailment prescription at the Project, changes in the curtailment protocol are applied as appropriate. While there is not a specific “trigger” that would call for a change in curtailment effort, there is the ability to adjust the existing protocol in response to observations by PacifiCorp, O&M staff, or other 3rd party contractor (as allowed by PacifiCorp). Additionally, adaptive management may range from small biomonitor activity modifications to larger protocol-based changes. For instance, if increased eagle activity occurs earlier than expected, or continues later than normal, PacifiCorp may elect to initiate the program outside of the current protocol assigned period. Table 1 summarizes the major adaptive management actions that have occurred during the curtailment program.

Table 1. Curtailment protocol changes over time at the Glenrock and Rolling Hills Wind Energy Facility.

Protocol Implementation/Change	Date(s)	Notes
Experimental curtailment initiated (test period)	November 2012	2 biomonitors, 5-days a week
Experimental curtailment (full scale)	December 2012 – March 2015	3 biomonitors, 7-days a week
Curtailment analysis/report	November 2014 - February 2015	Data provided to PacifiCorp to support long-term informed curtailment strategy
PacifiCorp informed curtailment decision	February 2015	PacifiCorp established the informed curtailment protocol (Oct – March, 7-days a week, 0900 – 1400 curtailment day)
Informed curtailment initiated	October 2015 – March 2016	First 6-month curtailment season (i.e., informed)
Curtailment towers constructed	October 2015	Two towers were constructed and outfitted for curtailment
Biomonitor manual curtailment protocol established	October 2015	Biomonitors were provided access to the SCADA system and trained to manually curtail turbines. This removed the radio call in to the O&M.
One month curtailment	September 2017	PacifiCorp initiated curtailment a month early
Additional biomonitor	November 2017 – February 2018	A third biomonitor was hired to conduct curtailment

PacifiCorp is committed to the informed curtailment program at the Project and will continue to evaluate the program's success, failures, and implementation into the future. Adaptive management will be used as needed throughout the life of the curtailment program.

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Appendix A: Curtailment Datasheets and Maps

EAGLE USE SURVEY DATA SHEET (Active Curtailment) Project Name: GRRH

DATE: ______________ OBSERVER ________ START TIME __________ END TIME__________ PAGE ______ OF _______

WEATHER: VISIBILITY (CIRCLE ONE) good fair poor CLOUD COVER (%)_________ TEMP(°F) _________

WIND DIRECTION (CIRCLE ONE) N NE E SE S SW W NW n/a SPEED (MPH) Low: _________ High: _________

PRECIPITATION (CIRCLE ONE) none light rain rain light snow snow sleet hail other

Obs No.	Time (Min)	**# Ind**	Closest turbine	Distance to Turbine	Observer location (turbine)	Activity (circle)					Flight Characteristics		Habitat		Notes
											Height (m)	Dir.			
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	OT	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
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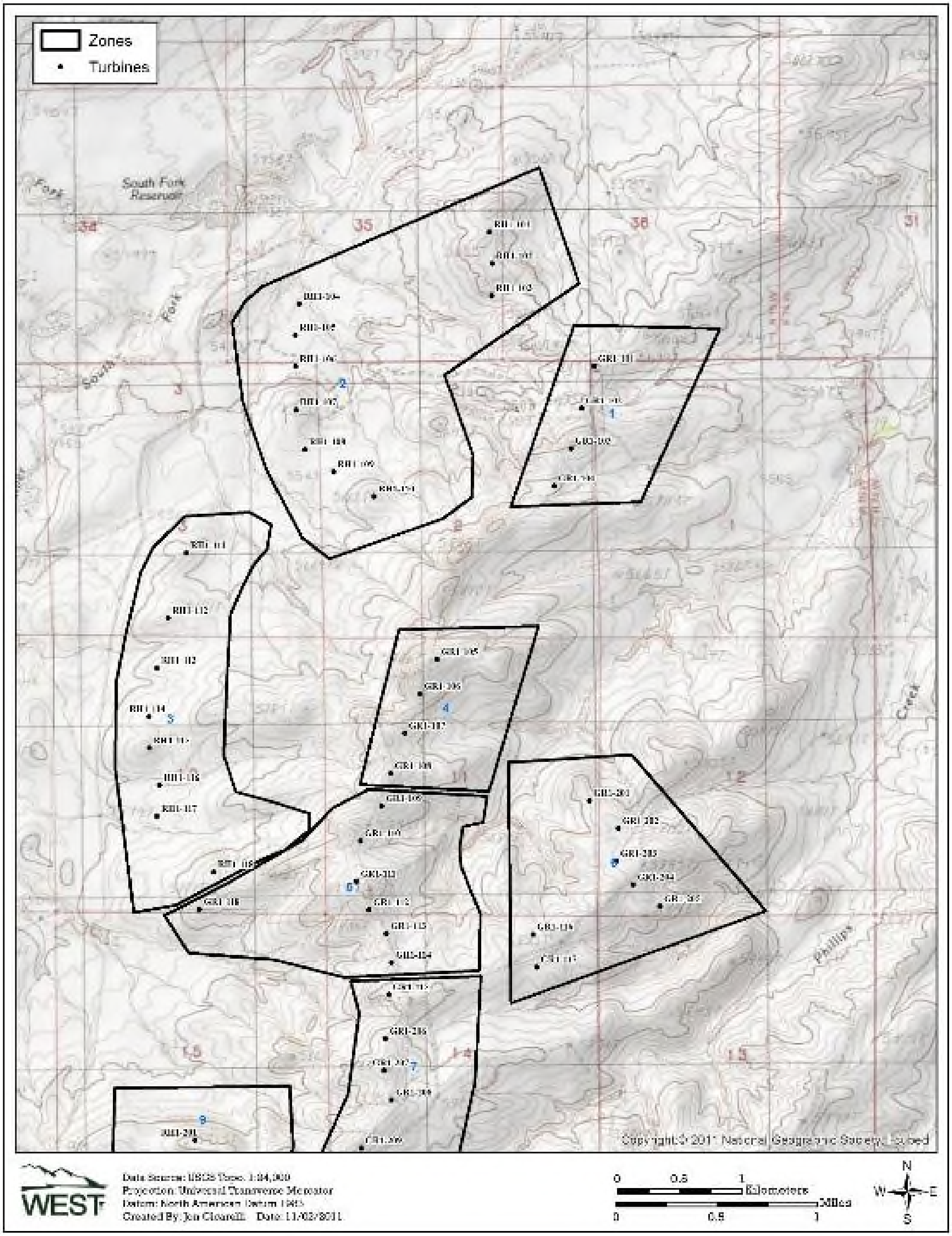
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	
						SO	FL	HU	ST	AG			SB	GR	
						PE	MO	TE	AU	CS			RO	FR	

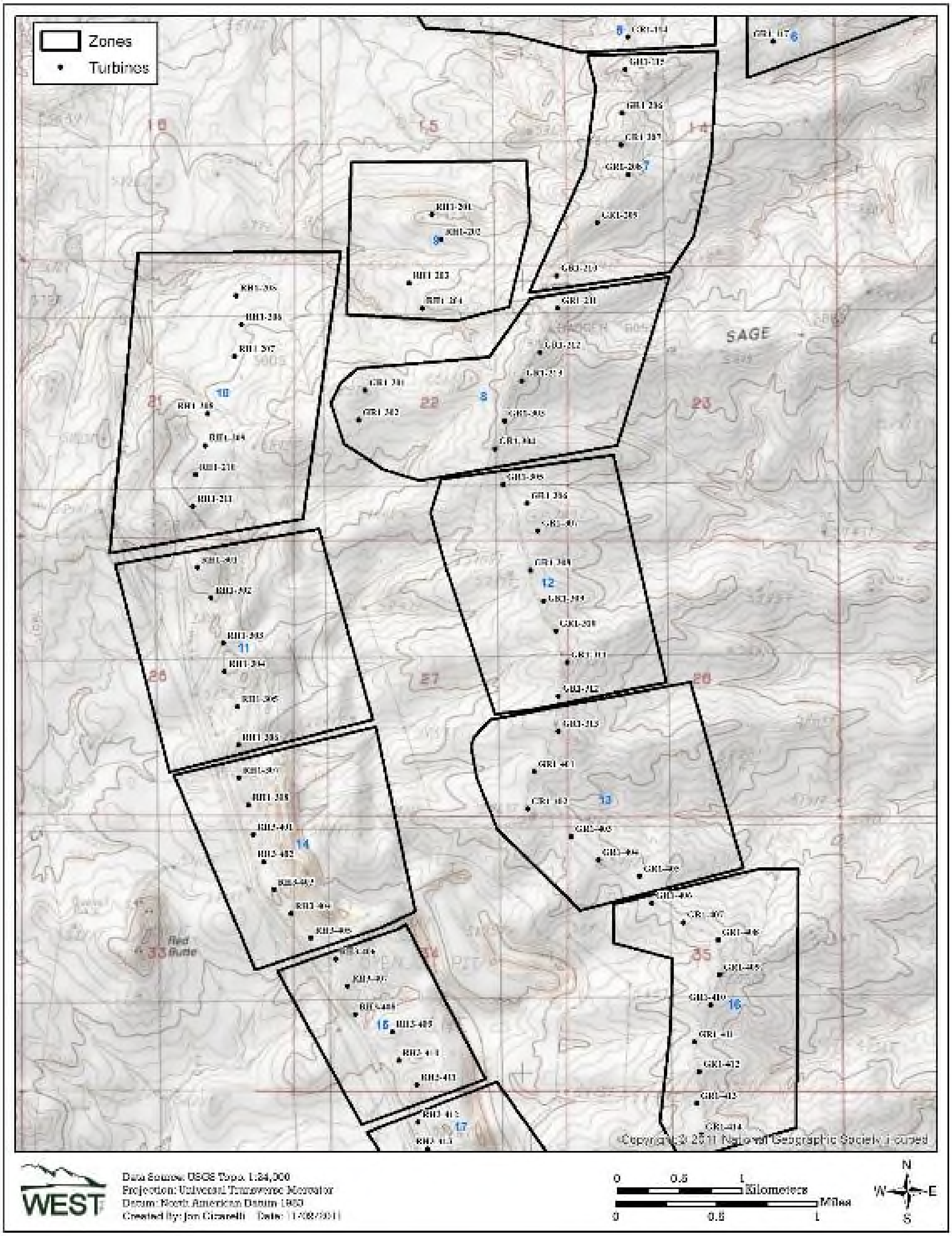
EAGLE OBSERVATION DATA SHEET **Obs: _____ Date: __________ Page ____ of ____**

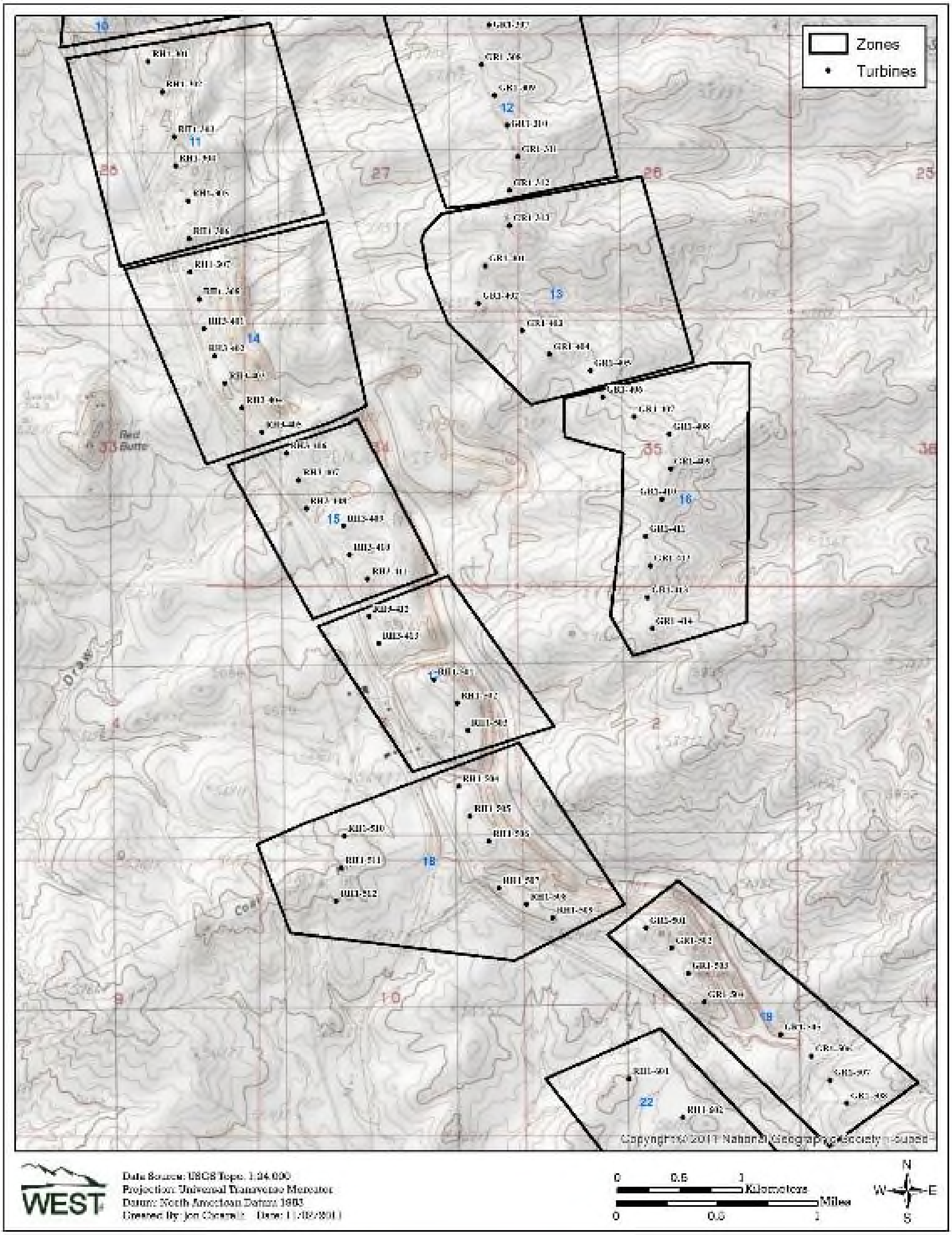
Active Curtailment Recommendation Log DATE:____________ OBSERVER ________ PAGE ______ OF _______

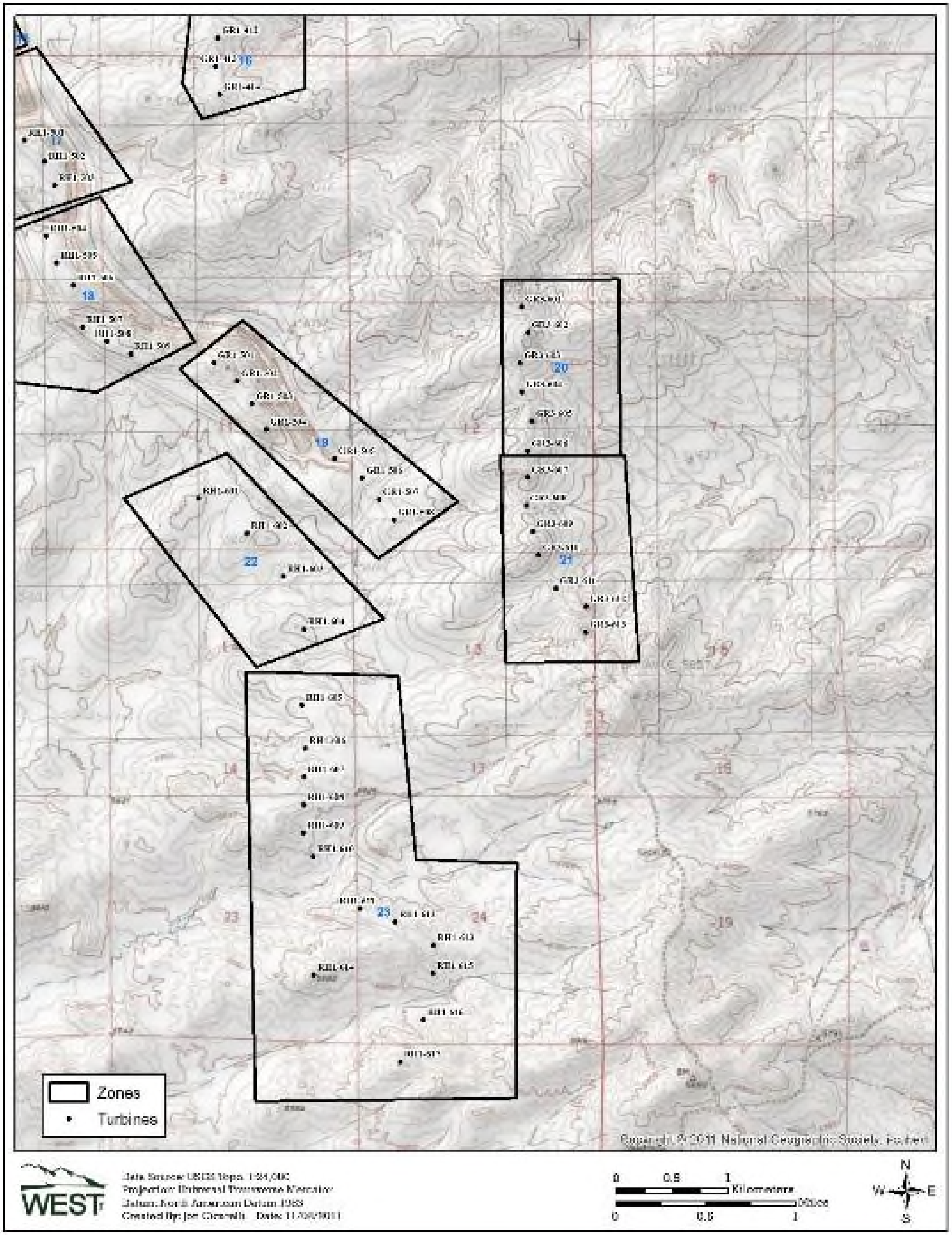
Obs No.	Active Curtailment Call in Time	Zone(s) Specified	All Clear Call in Time	Turbine Shutdown Time	Turbine Resume Time	**Specific Behavior(s) Observed** (flight direction, height, behavior, weather, supporting all clear observations, etc.)

EAGLE USE SURVEY DATA SHEET (Active Curtailment) **Obs:** _____ **Date:** __________ **Page** ____ **of** ____


Zones
Turbines
South Fork Reservoir
South Fork
Phillips
Creek
Copyright © 2011 National Geographic Society, i-cubed
WEST
Data Source: USGS Topo. 1:24,000
Projection: Universal Transverse Mercator
Datum: North American Datum 1983
Created By: Jon Ciarelli Date: 11/02/2011
0 0.5 1 Kilometers
0 0.5 1 Miles
N
W
E
S


Zones
Turbines
SAGE
Red Butte
Copyright © 2011 National Geographic Society
WEST
Data Source: USGS Topo 1:24,000
Projection: Universal Transverse Mercator
Kilometers
Miles
N
S
W
E


Zones
Turbines
Data Source: USGS Topo: 1:24,000
Projection: Universal Transverse Mercator
Datum: North American Datum 1983
Kilometers
Miles
N
S
W
E



Zones
Turbines
0 0.5 1 Kilometers
0 0.5 1 Miles
N
W
E
S

EAGLE USE SURVEY DATA SHEET (Informed Curtailment) Project Name: GRH Tower Location __________

DATE: ______________ OBSERVER ________ START TIME __________ END TIME__________ PAGE ______ OF _______

WEATHER: VISIBILITY (CIRCLE ONE) good fair poor CLOUD COVER (%)_________ TEMP(°F) _________

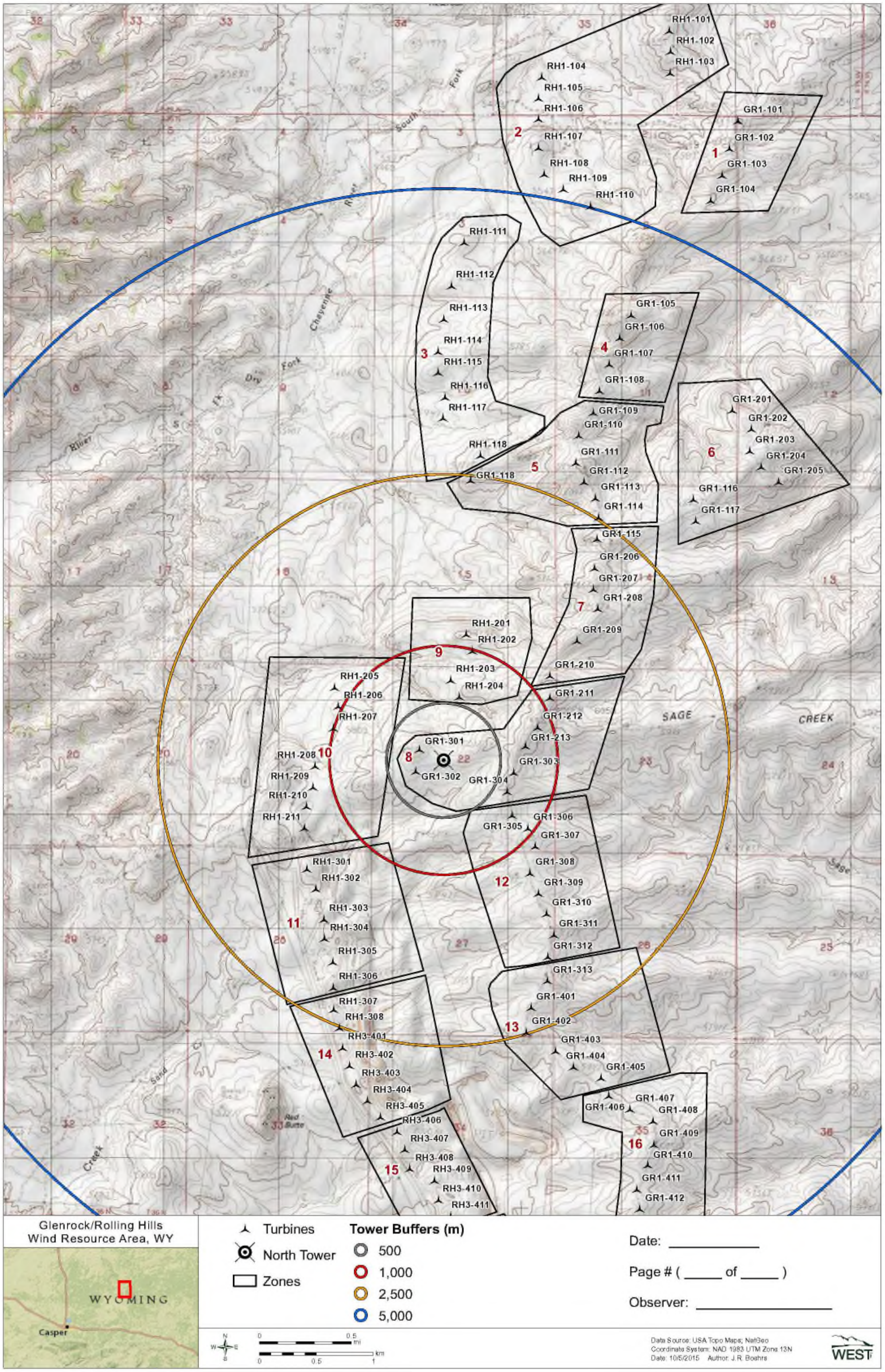
WIND DIRECTION (CIRCLE ONE) N NE E SE S SW W NW n/a SPEED (MPH) Low: _________ High: _________

PRECIPITATION (CIRCLE ONE) none light rain rain light snow snow sleet hail other

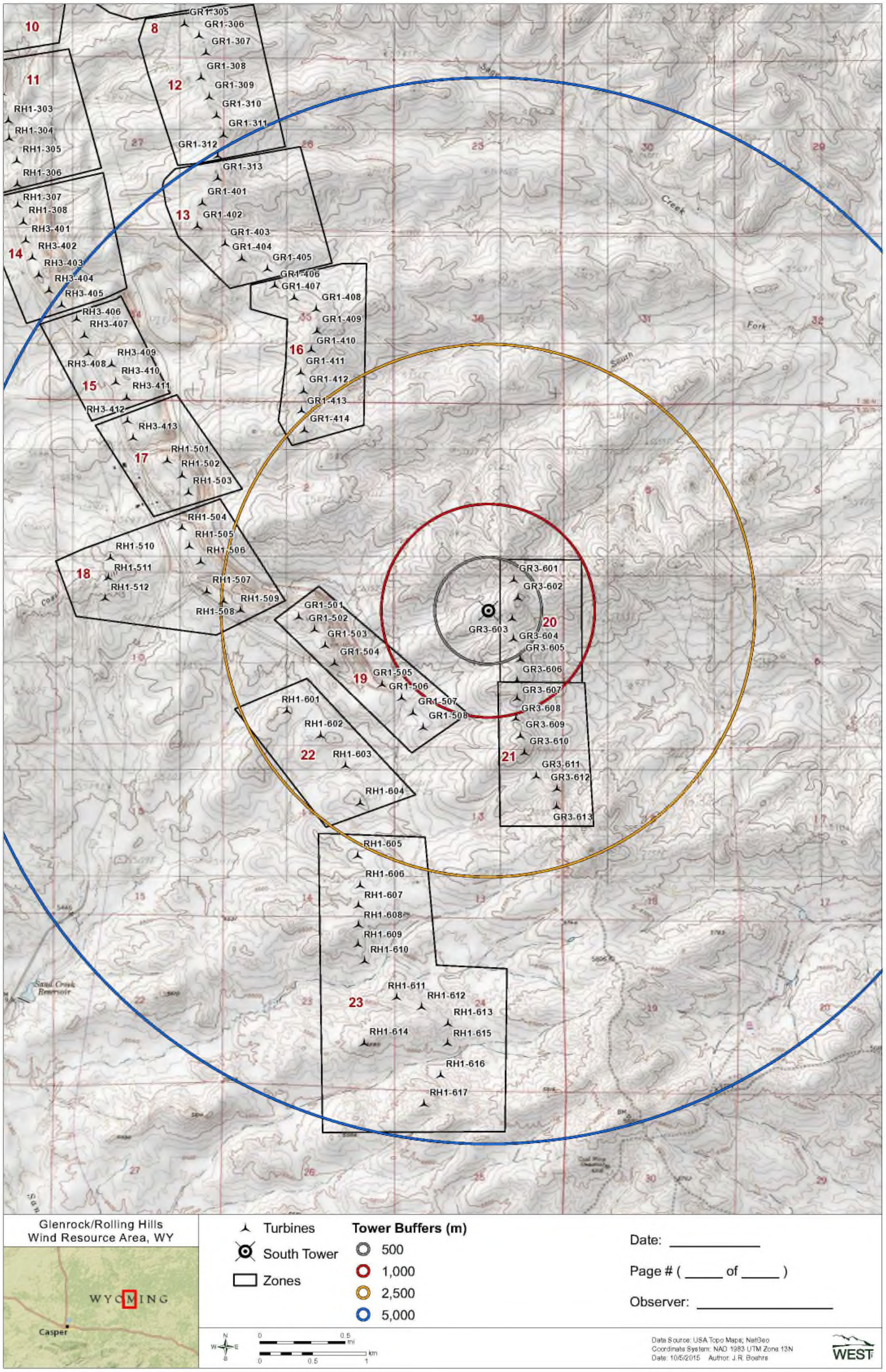
Obs No.	**Time** (Min)	**Activity** (circle)						**Flight Characteristics**		**Age** (A, SA, J, U)	**Notes**
								Height (m)	**Dir.**		
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				
		SO	FL	HU	ST	AG	KI				
		PE	MO	TE	AU	CS	OT				

Informed Curtailment Log DATE___________ LOCATION__________ OBSERVER _______ PAGE _____ OF ______

Obs No.	Active Curtailment Time	All Clear Time	Zone	Did curtailment occur in time (Y/N)	Number of passes through RSZ zone(s) of spinning turbines	Number of passes through RSZ zone(s) of stopped turbines	**Specific Behavior(s) Observed** (flight direction, height, behavior, weather, supporting all clear observations, etc.)



Glenrock/Rolling Hills
Wind Resource Area, WY
WYOMING
Casper
Turbines
North Tower
Zones
Tower Buffers (m)
500
1,000
2,500
5,000
Date: ____________
Page # (_____ of _____)
Observer: ________________
Data Source: USA Topo Maps; NatGeo
Coordinate System: NAD 1983 UTM Zone 13N
Date: 10/5/2015 Author: J.R. Boehrs
WEST
RH1-101
RH1-102
RH1-103
RH1-104
RH1-105
RH1-106
RH1-107
RH1-108
RH1-109
RH1-110
GR1-101
GR1-102
GR1-103
GR1-104
RH1-111
RH1-112
RH1-113
RH1-114
RH1-115
RH1-116
RH1-117
RH1-118
GR1-105
GR1-106
GR1-107
GR1-108
GR1-109
GR1-110
GR1-111
GR1-112
GR1-113
GR1-114
GR1-118
GR1-201
GR1-202
GR1-203
GR1-204
GR1-205
GR1-116
GR1-117
GR1-115
GR1-206
GR1-207
GR1-208
GR1-209
GR1-210
RH1-201
RH1-202
RH1-203
RH1-204
RH1-205
RH1-206
RH1-207
RH1-208
RH1-209
RH1-210
RH1-211
GR1-301
GR1-302
GR1-303
GR1-304
GR1-211
GR1-212
GR1-213
GR1-305
GR1-306
GR1-307
GR1-308
GR1-309
GR1-310
GR1-311
GR1-312
GR1-313
RH1-301
RH1-302
RH1-303
RH1-304
RH1-305
RH1-306
RH1-307
RH1-308
RH3-401
RH3-402
RH3-403
RH3-404
RH3-405
RH3-406
RH3-407
RH3-408
RH3-409
RH3-410
RH3-411
GR1-401
GR1-402
GR1-403
GR1-404
GR1-405
GR1-406
GR1-407
GR1-408
GR1-409
GR1-410
GR1-411
GR1-412
SAGE
CREEK



GR1-305
GR1-306
GR1-307
GR1-308
GR1-309
GR1-310
GR1-311
GR1-312
GR1-313
GR1-401
GR1-402
GR1-403
GR1-404
GR1-405
GR1-406
GR1-407
GR1-408
GR1-409
GR1-410
GR1-411
GR1-412
GR1-413
GR1-414
RH1-303
RH1-304
RH1-305
RH1-306
RH1-307
RH1-308
RH3-401
RH3-402
RH3-403
RH3-404
RH3-405
RH3-406
RH3-407
RH3-408
RH3-409
RH3-410
RH3-411
RH3-412
RH3-413
RH1-501
RH1-502
RH1-503
RH1-504
RH1-505
RH1-506
RH1-507
RH1-508
RH1-509
RH1-510
RH1-511
RH1-512
GR1-501
GR1-502
GR1-503
GR1-504
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GR1-507
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GR3-601
GR3-602
GR3-603
GR3-604
GR3-605
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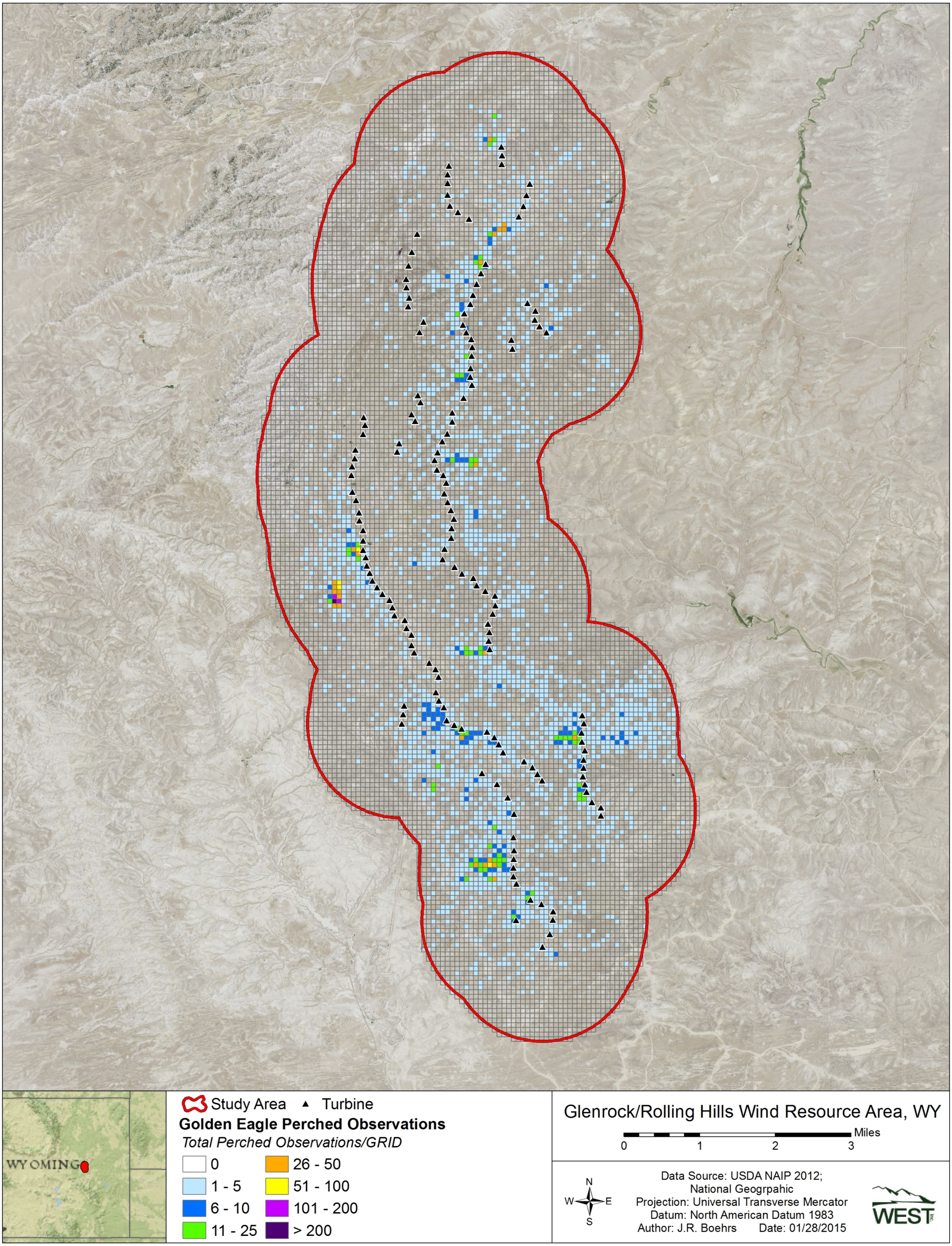
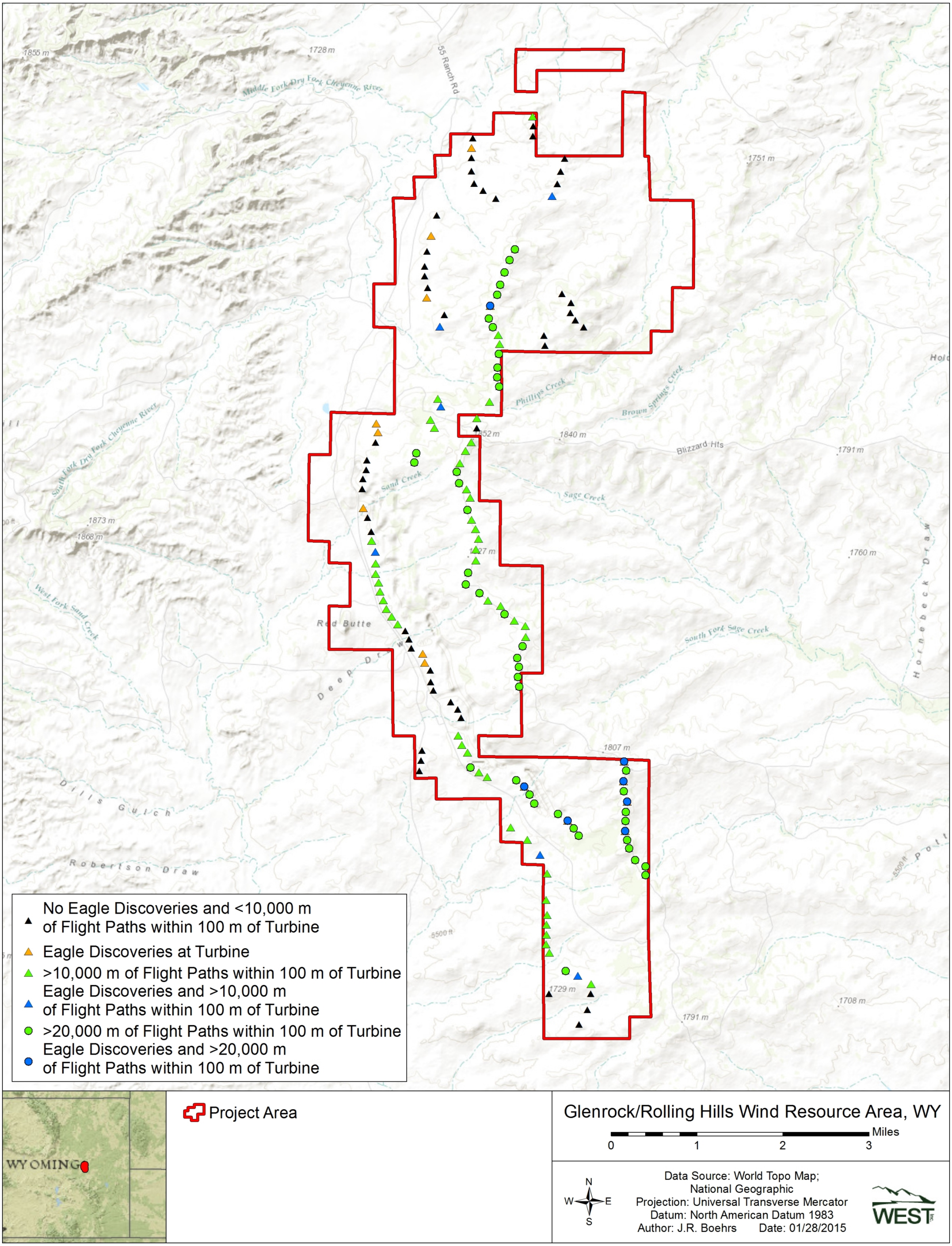
RH1-607
RH1-608
RH1-609
RH1-610
RH1-611
RH1-612
RH1-613
RH1-614
RH1-615
RH1-616
RH1-617
8
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Glenrock/Rolling Hills
Wind Resource Area, WY
WYOMING
Casper
Turbines
South Tower
Zones
Tower Buffers (m)
500
1,000
2,500
5,000
Date: ____________
Page # (_____ of _____)
Observer: __________________
0 0.5 mi
0 0.5 1 km
Data Source: USA Topo Maps; NatGeo
Coordinate System: NAD 1983 UTM Zone 13N
Date: 10/5/2015 Author: J.R. Boehrs
WEST

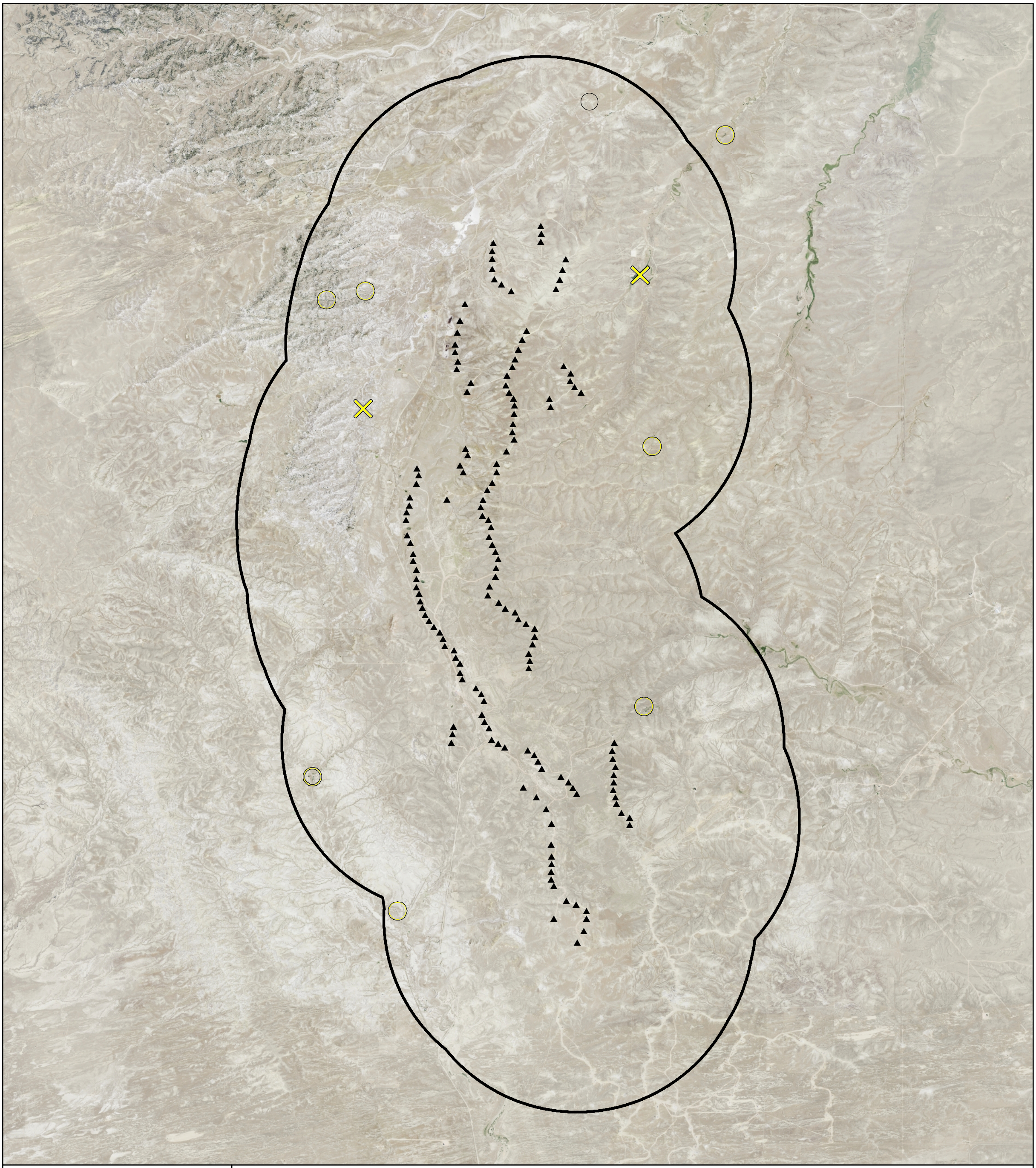
Appendix B – Additional Curtailment Resource Examples



WYOMING
Study Area
Turbine
Golden Eagle Perched Observations
Total Perched Observations/GRID
0
1 - 5
6 - 10
11 - 25
26 - 50
51 - 100
101 - 200
> 200
Glenrock/Rolling Hills Wind Resource Area, WY
Miles
0
1
2
3
N
W
E
S
Data Source: USDA NAIP 2012;
National Geogrpahic
Projection: Universal Transverse Mercator
Datum: North American Datum 1983
Author: J.R. Boehrs
Date: 01/28/2015
WEST



No Eagle Discoveries and <10,000 m of Flight Paths within 100 m of Turbine
Eagle Discoveries at Turbine
>10,000 m of Flight Paths within 100 m of Turbine
Eagle Discoveries and >10,000 m of Flight Paths within 100 m of Turbine
>20,000 m of Flight Paths within 100 m of Turbine
Eagle Discoveries and >20,000 m of Flight Paths within 100 m of Turbine
Project Area
WYOMING
Glenrock/Rolling Hills Wind Resource Area, WY
Miles
0
1
2
3
N
S
E
W
Data Source: World Topo Map; National Geographic
Projection: Universal Transverse Mercator
Datum: North American Datum 1983
Author: J.R. Boehrs
Date: 01/28/2015
WEST
Middle Fork Dry Fork Cheyenne River
55 Ranch Rd
South Fork Dry Fork Cheyenne River
Phillips Creek
Brown Springs Creek
Blizzard Hts
Sand Creek
Sage Creek
West Fork Sand Creek
Red Butte
Deep Draw
South Fork Sage Creek
Hornebeck Draw
Dills Gulch
Robertson Draw
1855 m
1728 m
1751 m
1840 m
1791 m
1873 m
1868 m
1760 m
1807 m
1729 m
1708 m
5500 ft



Glenrock/Rolling Hills Wind Resource Area, WY

Turbines

2.5 Mile Turbines Buffer

Raptor Nests - Round 1 Survey

Golden Eagle, Used

Golden Eagle, Vacant Nesting Territory

Great-horned Owl, Used

N W E S

0 0.5 1 1.5 2 2.5 mi

0 1 2 3 4 km

Data Source: USDA NAIP 2012; USGS Topo

Coordinate System: NAD 1983 UTM Zone 13N

Date: 3/18/2015 Author: J.R. Boehrs

WEST Inc.

Glenrock & Rolling Hills Wind Energy Facility

<u>Winter Protocol</u>

WEATHER CONCERNS

- Check road and weather conditions the night before you are scheduled to work and when you wake up. Ensure you are allowing time to communicate with co-workers and site personnel and still arrive onsite on time. Road condition and weather links are provided below.

  Road Conditions:

  http://map.wyoroad.info/hi.html

  http://www.wyoroad.info/

  Weather:

  http://preview.weather.com/weather/hourbyhour/l/USWY0069:1:US

  http://www.weather.com/weather/hourbyhour/graph/Casper+WY+82601

  http://www.wunderground.com/weather-forecast/US/WY/Rolling_Hills.html

- **If all roads are open and no weather concerns are apparent, proceed to the site as normal.**

- **If I25 is closed, do not drive to the site:**
  - Contact EDF to curtail default turbines;
  - Notify Luke about the situation;
  - Monitor the WYDOT and weather links for changing conditions;
  - Communicate with Luke, site personnel, and co-workers to determine if/when to proceed to site or if/when to cancel curtailment surveys for the day.

- **If roads are open, but weather and road conditions are questionable:**
  - GRH1 observer will contact site personnel (Casey Collins or other EDF personnel on weekends) to determine if site conditions warrant curtailment surveys;
  - GRH1 observer will contact GRH2 and GRH3 observers and provide an update;
  - If contact is not established with site personnel precede to the site;
  - Contact EDF to curtail default turbines any time observers are not onsite by sunrise.

DEFAULT CURTAILMENT

- Default curtailment must be implemented any time observers are not onsite between sunrise and sunset.
- Observers should curtail default turbines whenever visibility or site conditions are such that they cannot confidently observer eagles and curtail turbines; use 1000m as a rule of thumb, however professional judgment should be the deciding factor.
    - Maintain observation point in the field unless safety is a concern
    - Continue to curtail zones as appropriate
- If default curtailment is implemented for extended periods of time (e.g., +2hrs) and weather forecasts do not show signs of improvement, contact Luke to make a decision on ending curtailment surveys for the day.
- If default curtailment is on 2 hours prior to sunset and weather forecast does not show improvement, end survey in order to drive home safely.

GENERAL INFORMATION

- Allow extra time to travel to the site if there is precipitation on the roads or inclement weather. Observers are expected to arrive on time.
- Don’t park on turbine pads or walk under turbines if there is ice on the blades.
- Check common drift areas (road bends, draws, etc.) throughout the day to ensure roads are passable.
    - If road conditions are degrading, relocate to a location where roads are passable.
    - If all site roads are unpassable, proceed to the O&M and contact Luke to cancel surveys.
- Carry a shovel at all times.
- Engage 4WD on rental vehicles when site roads are icy, drifted, muddy, etc.
- If you get stuck make an effort to un-stick yourself first; if you are not able to un-stick yourself contact the closest WEST observer(s); only contact EDF or PacifiCorp personnel as a last resort. (Note: If close to sundown, contact help immediately)
- Notify Luke if you arrive late or end survey early.

Curtailment Observer Guidance:

- The number of individual birds per observations must remain constant
- For perched birds that aren't monitored, observers must identify a last observed time (whether it continues to perch or not)
- For birds perched at the end of the day, the end of observation time should match the end of survey day
- Start and end times should represent when active surveys took place…for example, time at O&M during lightning delays should not be captured in the survey time
- New observations should be collected whenever an observer loses sight of a bird
- Only GOEA should be collected and/or entered into database; other species observations should be collected/entered as 999 or zzzz or 0
- If curtailments are in place during rotations, it is the observer who called the curtailment's responsibility to listen for the all clear and document it on their datasheet
- If birds are in view at rotation time, the observation should end; then start again when the new observer enters the area
- This is not intended to be a min x min collections; however, the major points should be documented. This must include start time, end time, change in PE to FL or FL to PE, distance changes (greater than 500 m), flight height changes (relative to the RSZ)
- Observations beyond 2000 m do not need to be collected
- Flight paths should include obs #, direction arrow, "x" for perch point, be continuous.
- Recommend using different colors for each obs, new map when flight path lines start to get messy (~ 5 obs).

Curtailment Analysis Report
Glenrock & Rolling Hills Wind Energy Facility
Converse County, Wyoming

PacifiCorp Energy (PacifiCorp) has developed a three-phase wind energy facility in Converse County, Wyoming with a capacity of 237 megawatts (MW) from 158 GE 1.5-MW wind turbines. For the purposes of this report the three facilities were treated as one facility and referred to as the Glenrock & Rolling Hills Wind Energy Facility (GRHWEF).

In November 2012, consistent with the company's Eagle Conservation Plan and related documents, PacifiCorp initiated experimental active curtailment at the GRHWEF. Experimental active curtailment is an Advanced Conservation Practice consistent with the 2012 Wind Energy Guidelines (FWS 2012). Curtailment surveys were conducted five days a week in November and December 2012, then seven days a week starting in late December 2012 and continuing throughout 2013 and 2014. During curtailment surveys, three biomonitors documented turbine curtailment events and eagle observations. This report provides data collected from November 2012 through December 2014. For this analysis, only data which occurred during the 2-year period November 1, 2012 through October 31, 2014 were included. Data collected in November and December 2014 were checked to ensure consistency with 2012 and 2013 data. The purpose of this report is to summarize data on eagle use and turbine curtailment activities during the study period.

Golden eagle flying activity was highest in the 1200 hour (13.3% of all flying observations). Over 75% of the flying observations occurred from 1000 to 1600. Observations within the rotor swept zone were also highest during this time period. The number of eagles observed perching varied throughout the day, but the peak numbers were observed perching in the early morning. A downward trend in the number of eagles observed perching occurred throughout the remainder of the day, although increases in the number of perched birds were observed at around 1100 and 1400.

Approximately 72% of observation minutes were of perched eagles, while observation minutes of flying eagles accounted for 28%. Peak flying minutes (proportion) were observed in the 1200 hour (13.3%). Approximately 50% of the flying minutes (proportion) occurred from the 1100 – 1400 hour, while approximately 75% of the flying minutes (proportion) occurred within the 1000 – 1600 hours. Perch observation minutes (proportion) were greater in the morning; however, perching consistently occurred from the 0600 – 1600 hour.

More birds were observed flying than perched across all months. The greatest percentage (proportion) of flying observations occurred in December (17.6%), January (15.0%), November (14.7%), and February (13.0%). The lowest percentage (proportion) of flying observations occurred in from April – September (all less than 4.0%, proportion). June (2.7%) had the lowest percentage. The highest proportion of flights within the RSZ occurred from late fall to early spring (October – March). The lowest proportion of flights within the RSZ occurred from April – July. The highest percentage (proportion) of perch observations occurred in the winter (November – February).

Eagle observation minutes varied throughout the year. The highest percentage (proportion) of flying minutes occurred in December (18.1%), January (16.1%), November (15.0%), and February (12.0%). The lowest percentage (proportion) of flying minutes occurred in June (2.5%), May (2.8%), April (2.8%), and September (3.9%). The highest percentage (proportion) of perch minutes was recorded in February (19.1%), January (14.9%), and December (14.9%), while the lowest percentage (proportion) of perch minutes was recorded in April (1.7%), May (2.3%), and June (3.2%).

Eagle activity varied throughout the project area. Eagle activity was most concentrated in the south study area west of turbine string GR3-601 to 613 and in the north study area north and west of GR1-105 to 208. Other concentrated activity was located along the slope west of GR1-301 to 414. Flight paths tracked north and south above the slope. High activity was also recorded around Red Butte (west of RH3-403).

Analysis of topographical data suggests that as the slope increases, eagle observations increase. The increase is more evident at lower slopes. There was little difference in eagle activity as a function of aspect, although west aspects (225-315 degrees) had the highest proportion of flight paths, followed by north aspects (315-45). South aspects (135-225 degrees) and east aspects (45-135) had the lowest proportion of flight paths.

In general, activity by flying eagles increased with increasing wind speed. Eagle counts were relatively low at wind speeds < 7 m/sec. Eagle activity began to increase once wind speeds were 7 m/sec, and continued to increase until wind speeds were 12 m/sec. A small decrease in the proportion of eagle counts was observed when wind speeds ranged from 13-17 m/sec. A peak in activity occurred when wind speeds were at 19 m/sec; however, this was based on a limited number of survey hours. Perch counts were variable across most wind speeds. Less perching was observed when wind speeds were from 14-18 m/sec.

The number of turbine curtailments and minutes varied throughout the day. Approximately 50% of the curtailments occurred within the 1000 – 1400 hour period and greater than 75% occurred within the 0900 – 1700 hours. The number of turbine curtailments increased from sunrise until 1200, and then decreased over the remainder of the day.

Greater than 50% of the curtailment minutes occurred within the 1000 – 1500 hour period and approximately 75% of the curtailment minutes occurred from 0800 – 1600. Curtailment minutes increased from sunrise until the 1200 and 1300 hours, then decreased over the remainder of the day.

The number of turbine curtailments and minutes varied across the months of the year. The highest proportion of turbine curtailments occurred from October – March (78.5% combined). Proportion of curtailments by month over this period were December (15.9%), January (15.6%), November (14.4%), February (14.1%), March (9.3%), and October (9.2%). The lowest proportion of turbine curtailments occurred from April – September (21.7% combined).

The highest proportion of turbine curtailment minutes occurred from October – March (79.5% combined). Proportions of curtailment minutes by month during this period were February (17.1%), December (16.1%), January (16.0%), November (13.0%), March (9.1%), and October (8.2%). April – September had the lowest curtailment minutes (20.6% combined).

The 158 turbines were grouped into 23 zones for purposes of curtailment. Zones 20 (7.7%), 21 (7.9%), 19 (6.8%), and 23 (6.3%) had the greatest proportion of turbine curtailments. Zones 5, 8, and 14 each had at least 5% of the curtailments. Zones 1, 6, 9, 10, 15, and 17 had 2.5% or less of the curtailments. Curtailments occurred most often in the south section (37.2%; zones 18 – 23) and middle section (35.4%; zones 8 and 10 – 17) than the north section (27.5%; zones 1 – 7 and 9). Zones 23 (9.7%), 20 (8.7%), 21 (6.8%), and 19 (6.6%) had the greatest proportion of curtailment minutes. Zone 4, 14, 18, and 22 had at least 5% of the curtailment minutes. Zones 3, 6, 9, 10, 15, and 17 had less than 2.5% of the curtailment minutes. The south (42.0%; zones 18-23) had the highest percentage of curtailment minutes, followed by the middle (31.9%) and the north (26.1%).

Because eagle flying activity in very close proximity to turbines presents the greatest inherent risk, we also summarized the length of eagle flight paths within a 100 m-radius of turbines to further assess risk to golden eagles at the GRHWEF. We believe that this metric is likely the most closely associated with risk of any metric examined in this report. This analysis confirmed that risk to golden eagles is highest along Glenrock turbine strings GR3-601 to 613, GR1-411 to 414, GR1-501 to 508, and GR1-105 to 115. Risk along Rolling Hills turbines appeared low based on flights within 100 m; however, more golden eagle carcass discoveries have occurred at these turbines. Rolling Hills turbine strings with the highest risk are RH3-401 to 405, RH1-601 to 615, RH1-504 to 509, RH1-304 to 308, and RH1-201 to 206. Although some turbines with high activity did not have eagle carcass discoveries and others with low activity did, when eagle flight activity within 100 m of turbines was combined with data on where previous eagle carcass discoveries have occurred, there is a relationship between these two parameters, as most of the eagle carcasses were discovered at turbines with high eagle flying activity within 100 m, specifically along Glenrock turbines. Months with the highest mean length of eagle flight paths (per survey hour) within 100 m of turbines were January, February, March, October, November, and December.

During each of these months the mean length of flight paths within 100 m of turbines was well over 100 m/hr, with January, November, and December over 200 m/hr. In contrast, the months with the lowest mean length of flight paths within 100 m of turbines (April - September) each had less than 65 m/hr of flight paths within 100 m of turbines. The mean length of eagle flight paths within 100 m of turbines was highest in the 1200 hour (~200 m/hr), and was also relatively high (i.e., > 100 m/hr) from the 1000 through 1600 hour. Higher activity by eagles in close proximity to turbines also occurred at wind speeds greater than 9 m/sec.

Very little concrete evidence was available to quantify weather effects on eagle activity. Other research has shown greater eagle activity occurs near certain topographic features during high wind conditions. This was evident during this study. Other research has indicated that turbines placed near certain topographic features such as swales and rim edges would present greater risk. Golden eagle carcass discoveries at the GRHWEF have occurred near topographic features.

Prior to implementation of experimental active curtailment, the mean number of golden eagle carcass discoveries occurring per month at the GRHWEF was 0.34. Since implementing active curtailment the mean number of golden eagle carcass discoveries per month at GRHWEF was 0.30. Evaluating the effectiveness of curtailment is somewhat complicated due to the changes in protocol and discoveries for which time of death could not be determined. During the two full years of curtailment (2013 and 2014) where protocols were consistent the mean number of golden eagle carcass discoveries was 0.25/month. If the two golden eagle carcasses discovered in July 2013 (actual date of mortality likely prior to implementation of curtailment activities) are not included, the mean number of discoveries per month was 0.17 over the 24-month period.